THE SOYUZ--READY FOR FLIGHT

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Translation of "'Soyuz' k polëtu gotov," Aviatsiya i Kosmonavtika, No. 3, March 1975, pp. 38-39

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16. Abstract

Cosmonaut Filipchenko reports on the Soyuz. A December flight was made to test changes made in preparation for the joint flight of the Soyuz-Apollo. He describes in detail the experiments and tests which were made. Filipchenko pronounces it a complete success. He goes on to discuss the problems of rendezvous and docking of spacecraft from different countries.

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THE SOYUZ--READY FOR FLIGHT

Colonel A. Filipchenko

Before flight on the Soyuz-16, specialists asked us and /38* Nikolai Nikolayevich Rukavshinkov, if possible, to find any faults relating to operation of the modernized systems of the spacecraft. For the entire six days in orbit we did so. And we were glad not a single, even the smallest, trouble occurred; all of the instruments functioned faultlessly. Upon our return to Earth we reported to the State Commission that the Soyuz was ready for the coming Soviet-American space experiment.

As is known, on the basis of the agreement between the USSR and the USA on collaboration in research and utilization of outer space for peaceful purposes, in July 1975, a joint flight of the Soviet Soyuz spacecraft and the American Apollo spacecraft will take place; their basic mission will be testing elements of the joint system for rendezvous in orbit, androgynous docking devices, checking the techniques of reciprocal transfer of cosmonauts from ship to ship. As a result of this, experience will be gained on conducting combined flights of spacecraft from the USSR and the USA, and in case of emergency situations they will be able to give each other the necessary assistance.

Beside these basic tasks, it is planned that certain scientific and technical experiments will be carried out, direct television and radio transmission from both spacecraft, photographs and movies will be made.

The space experiment of the two countries will increase the safety of flights for man in space, and create conditions for other joint scientific experiments.

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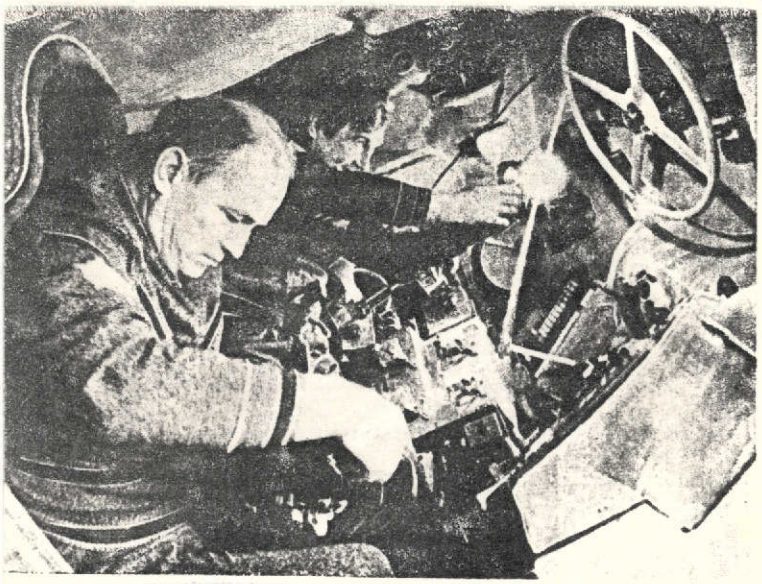
*Numbers in the margin indicate pagination in the foreign text.

Development of modified systems of the Soyuz was made during two flights of the Kosmos satellite series, and from the 2nd to the 8th of December, 1974 a test flight of the Soyuz-16 spacecraft was made with a crew on board. I was the commander of the ship, and the flight engineer was Nikolai Nikolayevich Rukavshinkov.



The crew of the Soyuz-16 spacecraft, Flight Engineer N.N. Rukavishnikov and Ship Commander A.V. Filipchenko, in training on the spacecraft trainer at the Center for Training Cosmonauts im. Yu. A. Gagarin.

At first glance it would appear that there will not be any basic technical difficulties in carrying out the joint flight of spacecraft in which USSR and USA and the Soyuz and Apollo spacecraft will participate.

Actually, the Soyuz and the Apollo have already completed a large number of flights. But one must not forget that they are spacecraft from different countries, and each country has approached and is approaching manned space flight coming from the development of its own science and engineering, from the scientific research carried out, experience acquired, in somewhat differing principles of constructing spacecraft and their systems. And in the coming flight there must be no kinds of obstacles. Therefore, one needs to attain compatibility of all systems interacting in the experiment with the spacecraft. This is not only for this flight but also for the future.

So that the spacecraft will be able to rendezvous

dock and exchange crews, it is necessary to plan compatibility of equipment for rendezvous, docking devices, lifesupport systems, equipment for communication and control of flight, equipment for transferring the cosmonauts.

Search, approach and docking require interaction of systems for measurement of parameters of movement of the spacecraft, control of their approach. Here one must attain coordination in operation of equipment for mutual maneuver and mooring; and angles of misalignment, linear and angular velocity at the moment of mooring must not prove to be beyond maximum sizes. It is necessary to plan that the exterior elements of the structure, the equipment of the spacecraft will not create intense reflected signals, that the antenna polar diagrams for use in the approach will not be distorted, in order to prevent collision of the advance elements of the structure when mooring and may other things must be planned for.

For bringing the spacecraft close together in orbit, various methods are used based on measuring certain parameters of their relative movement. For this, one utilizes both radio and optical equipment. Right now on Soviet and American spacecraft, these and others are used. However, they have certain differences. Therefore, in order to attain, for example, compatibility of radio equipment, it is necessary to have not only unified methods of measuring parameters of relative movement of the spacecraft, but also a single type of modulation, coordinated frequencies and power of transmitters, and the antenna polar diagrams.

The situation is considerably complicated if the spacecraft is in distress and its radio systems are out of order. The rescue ship in its search uses only optical equipment and equipment of a passive radar system. In this case, the efficiency of the reflective surface of the spacecraft takes on great importance both in the optical range and in the range of waves of the operating radar

set.

The androgynous peripheral docking unit (APAS [Androginnyy periferiynyy agregat stykovki APDU, Androgynous peripheral docking unit] which will be the equipment in the coming Soyuz and Apollo flight has already been described in a journal (see *"Aviatsiya i kosmonavtika"* No. 1, for 1974); we will add only that in spite of its large complexity in comparison with the docking devices existing up until now, the design of the APDU is promising and one can assume will be used in future manned spacecraft. Therefore, Soviet and American specialists unanimously agree on trying out the APDU even in the first joint space flight.

The androgynous structure of the docking unit, all elements of which mate and interact during docking, were developed by specialists in both countries. Nevertheless, Soviet and American units have differences. Each side has prepared its units for its own spacecraft independently. Compatibility is attained by unification of a few minimum elements, which are joined and come into contact during docking. As to the other elements, these were developed by designers and engineers completely independently.

Why was this done? Because on each side there is their own experience in creating similar devices, and no other solution was expedient. Also the dimensions and shape of this part of the ship where the new docking unit will be mounted is of considerable importance here. The interaction of manned spacecraft in flight, /39
besides docking, assumes the possibility of transferring crews from one spacecraft to the other--otherwise there would be no purpose in docking. But in order to do this one must have compatibility of a number of parameters of the systems of lifesupport of the spacecraft, and most important identical atmosphere in the living compartments.

If the atmosphere and pressure were uniform in composition,

everything would be simple: after docking, the crews having made sure of the hermetic seal between the spacecraft could open the hatches and move freely from one to the other.

A difference in atmosphere forces one to resort to a more complex system of transfer--adapting pressure in composition of the atmosphere of one spacecraft to the parameters of the apmosphere of the other. To do this, in principle, is possible in the living compartments of the spacecraft if their design and lifesupport system permit, and if there are special lock chambers and transfer compartments.

The difference in atmospheres in the Soyuz and Apollo is fairly high: our cosmonauts breathe a gas mixture which does not differ from ordinary air, but in the Apollo the atmosphere consists of pure oxygen under pressure, almost three times smaller than in the Soyuz. Therefore, in the coming flight, there will be a lock chamber for this in which the cosmonauts can equalize pressure and composition of the atmosphere. The transfer or docking module developed and manufactured on the American side especially for this flight will fulfill this role.

The joint flight of spacecraft of different countries requires compatibility of communication and control equipment. The cosmonauts must be able to converse with each other in flight, on approach and during docking. There is no way to manage without communication between the spacecraft and ground posts of both command-reference complexes. Interaction between the control centers for the flight is required. In a word, there must be regulated basic characteristics of radio communication, coordinated radio frequencies, type of modulation, sensitivity of receiving and transmitting devices. Precise order and shape of information exchange and conventional code is necessary.

In the future, obviously, for re-entry equipment of spacecraft

from all countries one cannot manage without standardization of equipment for communication and direction finding because only then will one be able to give help to another crew in case of an emergency landing in an unexpected region.

We have mentioned only the basic technical problems which require solution when preparing for joint flights of spacecraft from different countries. As a whole they are tremendous. Nothing has been said for example about the organizational coordination, which involves a wide circle of questions. The establishment of conformity in organizational structures and separation of their interacting elements is involved here, as well as knowledge of the language, regulation of terminology and conventional symbols, unification of coordinate systems, initial data for combined calculations, specification of documentation which provides interaction of all crews and exchange between them of information, coordination of methods for regulation in fulfilling operations, questions of training and preparation of cosmonauts and ground personnel.

Both countries have already accomplished a great deal in providing for the joint flight of the Soyuz and Apollo. The Soyuz-16 flight in space was an important step in this preparation. During the six-day orbital flight, tests were made on the new docking unit and its automation, systems for orientation and control, movement, lifesupport modernized in correspondence with the requirements for the coming Soviet-American experiment. When carrying out maneuvers orientation and stabilization of the Soyuz-16 spacecraft, the actions and operating conditions of the crew were developed for solving tasks identical to the tasks of the future joint flight. In these stages of flight, which occurred under conditions maximally approximating the conditions of the coming space experiment, the Soyuz-16 systems and equipment mounted on board operated normally. This is undoubtedly due to

the distinguished service of all the specialists who participated in preparing the spacecraft for flight.

In the six days in orbit the crew was saturated with tests, checking, and experiments.

I shall discuss a few of the problems of the program.

Up until now, all the spacecraft which have completed docking in orbit around the Earth started from a single spaceport. In the coming flight the Soyuz and the Apollo will be launched from different spaceports. This complicates the work considerably. On the 21st turn we were required to form a circular orbit which would pass over the American spaceport and allow the Apollo to form it. For this, two corrections are planned. They were made on the 2nd and 3rd of December. Preparation for the first correction began on the third turn, when in manual and automatic conditions the system for orientation and control of the movement was tested. On the fifth turn, after orientation at a point close to the perigee, the Soyuz was turned by engine along the velocity vector, then a braking impulse was given. On the seventeenth turn, the motor was swtiched on at the apogee, in this case, accelerated.

Thus, we "rounded off" the orbit. Its altitude was about 225 kilometers, the rotation period 88.9 minutes and inclination 51.8° which corresponded to the parameters which are required for the circular "fitting" orbit in the future joint flight.

Twice we carried out one of the most important operations for the future of flight. In the log book it was formulated thus: "experiment in giving the Apollo spacecraft the decision to start." This does not mean that the command to start for the American spacecraft will be given from orbit--for this the Conrol Center for Manned flights exists. But nevertheless, after seven and one half

hours from take-off the Soyuz must smoothly pass ober the American starting area and have an orbit which is as close as possible to the joint flight. Then our spacecraft will be prepared to rendezvous with the Apollo.

A great deal of attention was given in the Soyuz-16 flight to successfully testing the automatic system and separate units of the docking assembly. These units successfully passed testing in Houston (USA) on a dynamic test stand equipped with a complex of computers. They were set up in Moscow in the Institute of Space Research. But we wished to be convinced of the reliability of the unit in space: vacuum, tremendous drop in temperature, radiation all of these things are very hostile. Therefore, the Soyuz-16 was not only equipped with the new docking unit, but also with a special device which permits developing the most important and reliable operations for docking--drawing together, congruency, and actuation of latches. The ring of this device showed, on the docking unit of the Soyuz the same dynamic effects as on the actual Apollo. In a word, they were able to test this system even without a second ship in flight. The docking device was actuated without the least breakdown in desired kinematics of the component units and elements.

In order to avoid desaturation--washing out nitrogen from the bodies of the cosmonauts, which occurs every time when transferring a man from an atmosphere with high pressure to a atmosphere with low pressure, it was decided in the joint flight of the Soyuz and the Apollo to approximate the atmosphere inside the other spacecraft somewhat. This permits cutting down on the "stay" in the docking module of the Apollo during transfer and generally avoiding desaturation.

For the Soyuz to bring its atmosphere close to the atmosphere of the Apollo means decreasing its pressure and increasing the percentage content of oxygen.

This operation also had to be worked out in flight.

According to the test program of the modernized system of lifesupport, pressure in the compartments of the Soyuz-16 was decreased to 520 milimeters, mercury column, and in order not to disrupt the breathing processes, simultaneously the content of oxygen was increased to 40%. Tests showed that the system operated correctly, and we felt no discomfort.

In orbit, new radio equipment was tested: transmitters, receiver, antennas. When the Soyuz-16 flew over the dark side of the planet, flashing beacons were switched on. During the joint flight, the Apollo crew will be able to see them for about 50 kilometers.

In a word, this flight was made to check the readiness of the Soyuz for the coming Soviet-American space experiment. We are extremely pleased over the high evaluation which our work on the Soyuz-16 ship received. This evaluation for the work is for a large collective: those who participated in creating and testing the spacecraft, those who prepared its launching, facilitated its take-off, corrected its flight, those who helped us in studying the space engineering and operation of complex equipment.

Colonel A. Filipchenko
Pilot-cosmonaut of the USSR
Twice Hero of the Soviet Union